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WHAT DRIVES PARTICIPATION IN STATE VOLUNTARY CLEANUP PROGRAMS? EVIDENCE FROM OREGON

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Abstract

Over a quarter of a century after the passage of federal Superfund legislation, hundreds of thousands of properties contaminated with hazardous substances have yet to be remediated. To reduce this backlog, all but a handful of states have created Voluntary Cleanup Programs (VCPs) that offer liability relief, subsidies, and other incentives for responsible parties to voluntarily clean up contaminated properties. Yet we know little about what drives participation in these programs, in part because the requisite data are scarce. We analyze VCP participation in Oregon, one of a small number of states that maintains a data base of known contaminated sites. In contrast to previous VCP research, we conclude that Oregon's program does not mainly attract sites with little or no contamination seeking a regulatory "clean bill of health." Furthermore, we find that regulatory pressure—in particular, Oregon's practice of compiling a public list of sites with confirmed contamination—drives VCP participation. Together, these findings imply that Oregon has been able to spur voluntary remediation by disclosing information on contamination, a relatively inexpensive and hence efficient approach. Our results comport with key themes in the literature on voluntary environmental programs: the threat of mandatory regulation spurs participation in such programs, and disclosure of environmental performance information is an efficient policy tool for promoting abatement and remediation.

Key words: environment, hazardous waste, brownfields, contaminated property, duration analysis, Oregon

JEL codes: Q53, Q58, C41

1. INTRODUCTION

Over a quarter of a century after the passage of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund), hundreds of thousands of properties contaminated with hazardous substances have yet to be remediated (Simons 1998; Heberle and Wernstedt 2006). Part of the reason for this backlog is CERCLA itself which─by making liability for cleanup retroactive, strict, joint, and several─created incentives for property managers and developers to shun contaminated properties for fear of being saddled with the cost of cleanup. State "mini-superfund" laws with similar liability features may have compounded the problem. In addition, federal and state regulators typically only have resources to oversee cleanup of a relatively small number of severely contaminated sites (GAO 1997; Dana 2005).

To address these concerns, since the late 1980s, all but a handful of states have created programs that offer a basket of incentives for responsible parties and others to voluntarily remediate contaminated sites.[1] These incentives typically include relief from liability for future cleanup and/or third-party lawsuits; variable (versus uniform) cleanup standards that link the level of required cleanup to the future use of the site; flexible enforcement of environmental regulations; expedited permitting; and financial support for remediation through mechanisms such as grants, loans, subsidies, and tax incentives (EPA 2005). By 2004, roughly 20,000 contaminated sites had participated in, or were participating in, state voluntary cleanup programs (VCPs) (U.S. Environmental Protection Agency 2005).

Despite the prominent role that state VCPs now play in contaminated site policy, we know relatively little about the factors that drive participation in these programs─information that is needed to enhance their efficiency and effectiveness. This gap in the empirical literature is partly due to the difficulty of collecting the necessary information. Econometric analysis of participation requires data on contaminated sites that are not participating in the VCP—a control group—as well as those that are—a treatment group. But data on nonparticipating sites are scarce because contaminated properties may be "mothballed" to avoid detection and because state regulatory agencies lack the resources to identify them.

To our knowledge, only one econometric analysis of VCP participation has appeared. Alberini (2007) examines VCP participation in Colorado which, like most states, does not maintain a database of contaminated properties that are not participating in clean up programs. To construct a sample of nonparticipating sites, Alberini uses the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS), a national EPA registry of sites in need of investigation or cleanup. CERCLIS focuses principally on sites with relatively severe (confirmed or suspected) contamination that are candidates for the federal Superfund program. She finds that

[1] Federal legislation has also attempted to address these problems. The Small Business Liability Relief and Brownfields Revitalization Act of 2002 provided firmer statutory footing for expanded liability protection and authorized up to $200 million annually for site assessment and remediation and up to $50 million annually in assistance to state and tribal response programs.

Colorado's VCP mainly attracts sites with minimal contamination and high development potential not listed in CERCLIS. She concludes that

> ... these findings cast doubt on whether the VCP is truly attaining its original cleanup and environmental remediation goals and hints at the possibility that participation might be driven exclusively by the desire to rid the parcel of any stigma associated with the current or previous use of land (or to prevent such an effect with future buyers).

The present paper analyses VCP participation in Oregon, one of a small number of states that maintains a data base of contaminated sites, including those with minimal contamination. We use these data to construct a control sample.[2] In contrast to Alberini's findings for Colorado, we conclude that Oregon's VCP does attract sites with significant contamination. Furthermore, we find that regulatory pressure—in particular, Oregon's practice of formally compiling a public list of sites with confirmed contamination—drives VCP participation. Together, these findings imply that Oregon has been able to spur voluntary remediation by publicly disclosing information on contamination, a relatively inexpensive and hence efficient approach. Our results comport with key themes in the literature on voluntary environmental programs: the threat of mandatory regulation spurs participation in such programs, and public disclosure of environmental performance information is an efficient policy tool for promoting abatement and remediation.

The remainder of the paper is organized as follows. The second section reviews the literature on the factors that drive participation in voluntary environmental regulatory programs, and VCPs in particular. The third section provides background on Oregon's VCP. The fourth section discusses our data and variables. The fifth section presents our econometric model and the sixth section discusses our results. The final section offers conclusions.

2. LITERATURE

A considerable literature has developed to explain participation in different types of voluntary environmental initiatives including public programs administered by regulatory agencies, agreements negotiated between regulators and polluters, and unilateral private-sector commitments.[3] This section reviews the literature on participation in public programs, and VCPs in particular. It also briefly discusses a second relevant literature: that on public disclosure initiatives.

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[2] We sought to identify a state that both operates a VCP with a sufficiently large number of sites and that maintains a database of nonparticipating sites. Towards that end, we contacted regulatory authorities in 16 states (CA, CO, CT, IL, IN, KS, MA, MI, MO, NC, NC, NJ, OR, PA, TX, and WA) that have VCP programs with more than 100 participating sites according to EPA (2005). Of these states, four (CT, NC, OR, and MO) maintain data on nonparticipating sites.

[3] For reviews of this literature, see Lyon and Maxwell (2002), Alberini and Segerson (2002), and Khanna (2001).

2.1. Public programs

Empirical research on voluntary environmental public programs suggests that pressures applied by regulators, markets, and civil society drive participation. Variation in transactions costs associated with joining these programs also helps to explain why some actors participate and other do not.

2.1.1. Regulators

A leading hypothesis in the literature on voluntary environmental regulation is that private parties participate in order to preempt more stringent mandatory regulation, or to soften enforcement of existing regulation (Segerson and Miceli 1998; Maxwell, Lyon and Hackett 2000). Research on this "background threat" hypothesis as it relates to voluntary programs (as distinct from other types of voluntary regulation) has mostly focused on whether firms under pressure from regulatory authorities were more likely to join the U.S. Environmental Protection Agency's 33/50 program.[4] Khanna and Damon (1999), Videras and Alberini (2000), Sam and Innes (2006), and Vidovic and Khanna (2007) all find that firms named as potentially responsible parties at a higher-than-average number of Superfund sites were more likely to participate. Similarly, Videras and Alberini (2000) and Sam and Innes (2006) find that firms that were out of compliance with the Resource, Conservation and Recovery Act or Clean Air Act were more likely to join. The evidence about the impact of regulatory pressure on 33/50 participation is not one-sided, however. For example, Arora and Cason (1996) and Gamper-Rabindran (2006) find that firms that violated Clean Air Act requirements were not more likely to participate. As for research on other public voluntary programs, Videras and Alberini (2000) show that firms named as potentially responsible parties at a higher-than-average number of Superfund sites were more likely to participate in EPA's Waste Wi$e and Green Lights programs. Finally, Blackman et al. (2007) find that Mexican firms inspected and fined by the federal environmental regulatory agency were more likely to join the Clean Industry Program, a prominent national voluntary regulatory program.

Closely related to the hypothesis that regulatory pressure drives firms into voluntary programs is the notion that firms participate in order to obtain preferential treatment from regulators. Cothran (1993), for example, cites several case studies in which firms were able to obtain permits and regulatory variances in record time by undertaking voluntary environmental investments and maintaining good compliance records. Similarly, anecdotal evidence about Project XL, EPA's flagship voluntary program during the 1990s, suggests that firms obtained significant production cost advantages from participation, chiefly through relief from certain environmental regulations (Marcus, Geffen, and Sexton 2002). Decker (2003) provides econometric evidence that firms obtain permits for new facilities more quickly if they have engaged in voluntary abatement.

[4] Launched in 1991, the 33/50 program required participants to pledge to cut their emissions of 17 high-priority toxic chemicals by 33 percent by 1992 and by 50 percent by 1995.

2.1.2. Markets and civil society

Pressure brought to bear by consumers may also motivate participation in public voluntary programs. Theory suggests that firms may voluntarily improve their environmental performance to attract "green" consumers (Arora and Gangopadhayay 1995). Some empirical evidence suggests that this logic applies to participation in voluntary programs. For example, Arora and Cason (1996) and Vidovic and Khanna (2007) show that firms with a higher ratio of advertising expenditures to sales were more likely to participate in EPA's 33/50 program, and Videras and Alberini (2000) show that firms selling directly to final consumers were more likely to participate in the Waste Wi$e and Green Lights programs.

Pressures generated by communities and nongovernmental organizations may also create incentives for firms to join voluntary programs. Such pressures are the focus of the literature on so-called informal regulation, which mostly consists of cross-sectional, plant-level econometric analyses of environmental performance in developing countries (see World Bank 1999 for a review). For example, Blackman and Bannister (1998) find that in the early 1990s, pressures applied by industry and neighborhood organizations spurred participation in a voluntary clean fuels initiative targeting small Mexican brick kilns.

2.1.3. Transactions costs

The transactions costs associated with joining voluntary regulatory programs, including nonpecuniary learning costs, inevitably vary across firms. For example, transactions costs are likely to be lower for firms with a dedicated environmental management staff and experience dealing with regulatory agencies. Such variation in transactions costs may help to explain participation. For example, Blackman and Mazurek (2001) find that in a sample of 11 firms, transactions costs associated with participating in EPA's Project XL averaged over $450,000 per firm, varied considerably across firms, and appear to have deterred some firms from participating.

2.2. State voluntary cleanup programs

As noted in the introduction, to our knowledge, Alberini (2007) is the only published econometric analysis of participation in a VCP. However, a number of articles using other methods have examined a closely related topic: property managers' and developers' incentives to remediate contaminated properties. Alberini et al. (2005) and Wernstedt, Meyer, and Alberini (2006) present results of conjoint choice experiments designed to identify the type of policies that create incentives for real estate developers to remediate contaminated properties. Alberini et al. (2005) find that European developers can be attracted to contaminated sites by offering subsidies, liability relief, and less stringent regulation. Wernstedt, Meyer, and Alberini (2006) find that U.S. developers place a relatively high value on liability relief—from both cleanup costs and claims by third parties—and a relatively low value on reimbursement of environmental assessment costs.

They also find considerable heterogeneity in the value developers place on these incentives, depending on their experience with contaminated sites.

Research has also examined the impact of specific drivers of remediation including financial incentives, community support, and the level of contamination. Sherman (2003) analyzes various cleanup subsidies including property tax abatements, site assessment grants, development grants, and low-interest loans, and concludes that of these, property tax abatements are the most attractive to developers. However, he notes that financial incentives typically are not able to change developers' decisions about whether or not to remediate a contaminated property. Lange and McNeil (2004) present an analysis of survey data from 100 EPA brownfields grant recipients in the public sector and conclude that community support, consistency with local plans, and cost minimization, are the most important determinants of redevelopment success. Schoenbaum (2002) examines a sample of contaminated and uncontaminated properties in inner city Baltimore and fails to find a systematic relationship between contamination and the probability that a property was developed, suggesting that other factors such as access to transportation and crime rates play a more important role in developers' decision-making. However, McGrath (2000) finds that sites in Chicago that may have been contaminated were less likely to be redeveloped.

2.3. Public disclosure

In addition to the literature on voluntary environmental public programs (including state voluntary cleanup programs), the literature on public disclosure is also relevant. Public disclosure initiatives collect and disseminate data about private parties' environmental performance in order to both inform the public about threats to their health and the environment, and to strengthen private incentives for pollution control and remediation (Teitenberg 1998). Often characterized as the "third wave" of environmental regulation (after command-and-control and market based approaches), public disclosure has grown increasingly popular over the past 20 years, in part because it is viewed as a relatively inexpensive environmental management tool (Kerret and Gray 2007; Dasgupta, Wheeler and Wang 2007).

A principal concern of the economics literature on public disclosure has been testing its efficacy in improving environmental quality. Although evidence about the U.S. Toxic Release Inventory (TRI), arguably the best-known public disclosure program, is mixed (Bui 2005; Greenstone 2003; Koehler and Spengler 2007), studies of other programs have generated compelling evidence of that public disclosure can drive emissions reductions. These programs include: so-called performance evaluations and ratings initiatives in Indonesia and India that not only disseminate raw emissions data, but also use it rate the performance of participating plants (García et al. 2007; Powers et al. 2008); 1996 amendments to the U.S. Safe Drinking Water Act mandating that community drinking water systems publicly report regulatory violations (Bennear and Olmstead 2007); rules requiring U.S. electric utilities to publicly report the extent of their reliance on fossil fuels (Delmas, Montes-Sancho, and Shimshack 2007); and a policy of publicizing the identity of plants that are noncompliant in British Colombia (Foulon, Lanoie, and Laplante 2002).

A second focus of the literature on public disclosure has been understanding how it drives emissions reductions. Research on this topic suggests that public disclosure leverages many of the same pressures discussed in the literature on public voluntary programs including those generated by regulators, markets and civil society (Bennear and Olmstead 2007; Dasgupta et al. 2006). In addition, some studies suggest that public disclosure motivates improved environmental performance partly by simply improving plant managers' information about their own emissions and abatement options (Blackman et al. 2004; Dasgupta, Wheeler, and Wang 2007).

3. OREGON'S CLEANUP PROGRAMS

This section discusses the data that Oregon collects on contaminated properties and its mandatory and voluntary clean up programs

3.1 The Environmental Cleanup Site Information database

Oregon's Department of Environmental Quality (DEQ) maintains an Environmental Cleanup Site Information (ECSI) data base, which in July 2006 contained information on 4,223 contaminated, potentially contaminated, and formerly contaminated sites.[5] The sites in the database came to the attention of DEQ in a variety of ways including corroborated citizen complaints and referrals from other regulatory programs such as DEQ's hazardous waste program and the federal CERCLIS.[6] The criterion for inclusion in ECSI is simply that a site is known to be, or suspected to be, contaminated. ECSI contains a variety of data about sites including their location, former and present uses, ownership, and any remedial actions that have been performed. ECSI also contains information on all DEQ actions and decisions regarding each site.

DEQ maintains two lists that are subsets of ECSI: the Confirmed Release List, and the Inventory of Hazardous Substance Sites. The Confirmed Release List consists of sites where contamination has been confirmed (by qualified observation, operator admission, or laboratory data), has been deemed "significant" by virtue of its quantity or hazard, has not been regulated under another program, and has not been adequately cleaned up or officially deemed to require no further action. Placing a site on the Confirmed Release List, subjects its managers to enhanced pressures from both regulatory and nonregulatory actors. Managers can be required to participate in DEQ's mandatory clean up program and may have difficulty transacting their property. Hence, "listing" is a serious regulatory action. Prior to listing, DEQ notifies site managers of their intent to do so, and gives them an opportunity to comment and provide additional information. In addition, DEQ provides a public comment period prior to delisting a site that has completed requisite clean up. The Inventory of Hazardous Substance Sites is a subset of the Confirmed

[5] Including 377 "candidate" or "historical" sites that are not considered fully fledged entries. ECSI is not comprehensive; it does not include a significant number of sites about which DEQ has not information.
[6] ECSI excludes sites with petroleum releases from underground storage tanks.

Release List. It comprises sites on which contamination is considered a threat to human health or the environment and must be cleaned up.

3.2. Oregon's mandatory and voluntary cleanup programs

Oregon has three clean up programs for contaminated sites: the Site Response Program, the Voluntary Cleanup Program (VCP), and the Independent Cleanup Pathway (ICP). The Site Response Program is DEQ's mandatory program. DEQ classifies all sites as "high," "medium," or "low" priority for further regulatory action. The Site Response Program is reserved for high-priority sites (although not all such sites are required to participate). For sites in this program, DEQ provides oversight throughout the investigation and cleanup and selects the remedial action. Of the 4,223 sites in ECSI, 10% are participating in, or have participated in, the Site Response Program.

The VCP and ICP are DEQ's voluntary cleanup programs. Both the VCP and ICP are targeted at medium- and low-priority sites. However, high priority sites are allowed to participate in the VCP but not the ICP. The ICP, and to a lesser extent the VCP, entail lower levels of DEQ oversight than the mandatory Site Response Program. Of the 4,223 sites in ECSI, 27% have participated in, or are participating in, the VCP and 7% have participated in, or are participating in, the ICP.

The mechanics of participation in the VCP are as follows. Site managers submit an "intent to participate" form and deposit $5,000 in an account that DEQ may draw upon to cover administrative expenses. Next, DEQ reviews written documentation on the site, visits the site, and works with the site manager to develop a cleanup plan. DEQ holds a public comment period and then decides whether or not to approve, disapprove, or modify the cleanup plan. If the plan is approved, the site manager implements it. When implementation is complete, DEQ invites public comment again and, barring serious objections, issues either a "no further action" (NFA) determination that provides assurance that DEQ will not require further remediation, or a conditional NFA that provides this assurance contingent upon the site manager undertaking certain actions, such as land use control.

DEQ promotional materials list a set of benefits and risks of participating in the VCP (DEQ undated a). The benefits include DEQ guidance and oversight, possible exemptions from permits for on-site work, and DEQ permission to redevelop part of the site while cleanup is ongoing on other parts. Among risks are that all sites joining the program are added to ECSI, and that sites that fall behind in their implementation of cleanup plans can be forced to join the mandatory Site Response Program.

The ICP entails less DEQ oversight than the VCP. Essentially, site managers who pass an initial screening are allowed to complete an investigation and cleanup independently and then request final approval from DEQ. That said, ICP participants can access DEQ oversight if they want it and are willing to pay for it. According to ICP promotional materials, among the risks of participation are that DEQ may not approve of independently planned and implemented cleanups. Also, DEQ does not provide permit waivers to ICP participants (DEQ undated b).

DEQ recruits participants in the VCP and ICP by sending invitation letters to the managers of ECSI sites where DEQ has determined that further action is needed. The vast majority of such letters simply describe the programs. The remainder, which are sent to high-priority sites only, essentially give site managers an ultimatum: either join the VCP, or be forced to participate in the mandatory Site Response Program. Of the 1,318 sites in the ECSI database that are participating in, or that have participated in the VCP or ICP, 1,142 (87%) joined after being included in the ECSI database and receiving an invitation letter. The remaining sites were unknown to DEQ before they submitted an application to join.

4. ANALYTICAL FRAMEWORK, DATA AND VARIABLES

This section describes the analytical framework, data, and variables we use to analyze participation in the VCP and ICP.

4.1. Analytical framework

We assume that a site manager will join the VCP or ICP if the net benefits (benefits minus costs) of doing so are positive. The benefits include: (i) the expected savings in transaction costs and cleanup costs that arise from avoiding the mandatory Site Response Program, which entails less discretion choosing how and how much to remediate, less regulatory flexibility (e.g., expedited and waived permits), and a higher level of DEQ oversight; (ii) the avoided future liability costs from obtaining an NFA; (iii) the expected appreciation in property value from remediation and obtaining an NFA over and above the savings in cleanup and liability costs; and (iv) the expected reduction in costs imposed by neighbors, community groups, environmental non-governmental organizations, and other stakeholders concerned about contamination. The costs of participation include: (i) pecuniary transactions costs such as DEQ administrative fees; (ii) pecuniary and nonpecuniary transactions costs involved in learning about the VCP and ICP and negotiating the DEQ bureaucracy; (iii) costs of any actual cleanup; and (iv) for sites that are unknown to DEQ, the cost of informing DEQ about potential contamination, including costs associated with being added to ECSI.

We expect these benefits and costs of participation to vary across sites, so that net benefits of participation are positive for some sites and negative for others. We do not directly observe benefits and costs. Using the ECSI along with data from block group-level census data, however, we can observe site characteristics that proxy for these costs. We use these proxies as explanatory variables in our regression analysis. In Section 4.2 below we discuss the relationship between these proxies and the net benefits of participation.

4.2. Regression samples

We cannot run a single regression to explain participation in VCP and ICP because the subsample of non-participating sites is different for each program: as noted above, high priority sites are eligible to participate in the VCP, but not in the ICP. Therefore, we constructed two samples of ECSI sites, one to explain participation in the VCP, and one to explain participation in the ICP.

The first several steps of the data base assembly were the same for each of the two samples. First, we used geographic information system software to associate each ECSI site with a census block group and merged the site-level ECSI data with block-group level census data. Of the 4,223 sites in ECSI, 458 had to be dropped either because locational information (latitude and longitude) was missing in the ECSI data, or because block group data was missing in the census data. Next, we dropped 340 sites that were ineligible to join the VCP or ICP because they were participating in the mandatory Site Response Program (319 sites), or were listed on the federal National Priorities List (11 sites). We also dropped 120 ECSI sites that received an “ultimatum” letter from DEQ warning them that if they did not join the VCP, they would be forced to join the mandatory Site Response Program. We dropped these sites because their participation in the VCP was not fully voluntary. In addition, we dropped four sites that DEQ declared “orphans” because a responsible party could not be identified. Finally, we dropped 1,506 sites for which ECSI did not contain enough information to determine the prior industrial or other use of the site. The result was a data set containing 1,805 sites.

To create the sample used to analyze the VCP—which we will call the “VCP sample”—we dropped an additional 125 sites for which the VCP join data was inconsistent (because join date preceded the date the site was entered into ECSI), leaving a total of 1,680 sites, 613 (36%) of which participated in the VCP.

To create the sample used to analyze the ICP program—which we will call the “ICP sample”—starting with the data set of 1,805 sites, we dropped 124 additional sites DEQ deemed to be high priority for further action because such sites are not eligible to participate in the ICP. In addition, we dropped 39 sites for which the ICP join date was inconsistent (again because join date preceded the date the site was entered into ECSI), leaving a total of 1,642 sites, 155 (9%) of which participated in the ICP.

4.3. Variables

Table 1 lists the variables used in the econometric analysis and for each sample, presents means for the entire sample and for the subsamples of participants and nonparticipants. We use three types of variables to explain participation in the VCP and ICP: (i) dummy variables that have to do with DEQ regulatory activity; (ii) continuous variables that capture the characteristics of the neighborhood in which the site is located; and (iii) dummy variables that control for the type of industrial or commercial activity found on each site. We are not able to include explanatory variables derived from the information in ECSI on that ranks the severity of contamination ("high," "medium," "low") because this information is missing or unreliable for the majority of the sample.

4.3.1. Regulatory activity variables

Among the regulatory activity variables, *CRL* is a dummy variable that indicates whether DEQ placed the site on the Confirmed Release List. As Table 1 shows, DEQ "listed" roughly a quarter of the sites in the VCP and ICP samples. We expect *CRL* to be positively correlated with participation because, as discussed above, when DEQ lists a site, it is subjected to enhanced pressures to clean up from regulators and other actors such as mortgage lenders. For example, listing increases the chances that the site manager will be forced into the mandatory Site Response Program and will be denied bank credit. Thus, all other things equal, we expect the net benefits of participation to be higher for sites that have been included on the Confirmed Release List. Table 1 provides a preliminary indication of a positive correlation between listing and participation in the VCP. In the VCP sample, the percentage of sites that were listed was much higher among VCP participants (42%) than nonparticipants (16%). This seeming positive correlation between *VCP* and *CRL* does not prove that listing causes participation, however, because it may simply reflect an underlying correlation between *CRL* and another site characteristic. For example, it could reflect the fact that sites used for manufacturing tend to participate, and also tend to be listed. Alternatively, or in addition, it could reflect the effect of *VCP* on *CRL*, that is, it could be that sites that participate are subsequently listed. As discussed below, to control for site characteristics and potential endogeneity in *CRL* and other regulatory variables, we use a duration model that explicitly accounts for the timing of participation, listing, and other regulatory activities.

CERCLIS is a dummy variables that indicates whether the federal government includes the site in CERCLIS, which, as discussed above, is a database used by the U.S. Environmental Protection Agency (EPA) to track activities conducted under its CERCLA authority. We expect that *CERCLIS* is positively correlated with participation in the VCP and ICP because inclusion in this federal list, like inclusion in ECSI, presumably enhances regulatory and non-regulatory pressures to cleanup and thereby increases the net benefit of participation.

PERMIT is a dummy variable that indicates DEQ has issued a permit to the site manager, whether for air emissions, liquid effluents, or hazardous waste. About a sixth of the sites in our two regression samples received permits from DEQ. We expect *PERMIT* to be positively correlated with participation for two reasons. First, all other things equal, DEQ likely has more comprehensive and more accurate information about potential contamination on permitted sites than on nonpermited sites. As a result, one of the main costs to site managers of participation—revealing information about potential contamination to DEQ—is lower for permitted sites. Second, by virtue of their ongoing contacts with DEQ, permitted sites likely have more accurate and more comprehensive information about the VCP and ICP than do nonpermitted sites (Wistar 2006). As a result, their costs of participation are lower.

Finally, we include dummies that indicate which of the three DEQ regional offices (east, west, and northwest) are responsible for administering the site: W_REGION, and NW_REGION (the east region is the reference category). The west and northwest regions each have approximately 37% of the sites in our samples, while the east region has roughly 26%. These dummies aim to control for differences in program administration across the three regions that affect the net benefits of participation. We have no strong expectations about the signs of these dummies.

4.2.2. Community characteristics variables

We include two variables that measure potentially relevant characteristics of the communities in which the site is located. *HOUSEVAL*, the median housing value in the relevant census block group, aim to capture the market value of the site.[7] To the extent *HOUSEVAL* is a good proxy for market value, we expect it to be positively correlated with participation for two reasons. First, site managers and developers may have stronger financial incentives to remediate more valuable properties. Also, contamination on particularly valuable sites may attract more attention from regulators, neighbors, and others.

TR_TIME, the median travel time to work in minutes in the relevant census block. It is included to control for locational factors that might influence a site manager's decision to participate including the market value of the site and proximity to companies that provide remediation services. We expect this variable to be negatively correlated with participation (as is distance to central business district in Alberini 2007) because sites located farther from business districts may be less valuable and may attract less attention from regulators, neighbors and others.

4.2.3. Prior use variables

Finally, we include 14 dummy variables, *SIC1–SIC 14*, that indicate the two-digit SIC code most closely associated with the site's prior commercial or industrial use. These variables are intended to control for a variety of site characteristics including size, complexity, and the nature of the contamination. In our regression samples, the categories

[7] We also collected data on commercial property values compiled at the county level for tax assessment purposes. However, we were unable to use these data in our regression analysis because most Oregon countries do not collect the data needed to locate the properties in the appropriate census block group or to control for property size.

with the greatest proportion of sites are SIC8 (transportation, communications, electricity, gas and sanitary) with roughly 18%; SIC 12 (services including dry cleaning and auto repair) with roughly 17%; SIC10 (retail trade) with 11%, and SIC4 (manufacture of wood products) with roughly 10%. Although ECSI contains more direct information on site characteristics, including the size and current operational status, these data are too incomplete to be used in our analysis.

5. ECONOMTRIC MODEL

We use a duration model to analyze participation in the VCP and ICP. Such models are used to explain intertemporal phenomena, such as the length of time that patients with a life-threatening disease survive, and the length of time industrial facilities operate before adopting a new technology.[8] Duration models estimate a hazard rate, h, which may be interpreted as the conditional probability that a phenomenon occurs at time t given that it has not already occurred and given the characteristics of the unit of analysis (patient, plant) at time t. The hazard rate is defined as

$$h(t, \mathbf{X_t}, \beta) = f(t, \mathbf{X_t}, \beta)/(1- F(t, \mathbf{X_t}, \beta)) \qquad (1)$$

where $F(t, \mathbf{X_t}, \beta)$ is a cumulative distribution function that gives the probability that the phenomenon (death, adoption of a technology) has occurred prior to time t, $f(t, \mathbf{X_t}, \beta)$ is its density function, $\mathbf{X_t}$ is a vector of explanatory variables related to the characteristics of the unit of analysis (which may change over time), and β is a vector of parameters to be estimated. In our study, the hazard rate is the conditional probability that a site in our data set joins the VCP or ICP program at time t, given that it has not already joined and given the characteristics of the site at time t.

In duration models, the hazard rate is typically broken down into two components. The first is a baseline hazard, $h_0(t)$, that is a function solely of time (not of any explanatory variables) and that is assumed to be constant across all plants. The baseline hazard captures any effects not captured by explanatory variables (such as the diffusion of knowledge about the VCP and ICP or changes in macroeconomic conditions). The second component of the hazard rate is a function of the explanatory variables. Combining these two components, the hazard rate h(t) is written

$$h(t) = h_0(t)\exp(\mathbf{X_t}'\beta). \qquad (2)$$

The vector of parameters, β, is estimated using maximum likelihood.

A duration framework is appropriate for analyzing participation in the program for two reasons. First, two of the regulatory activity variables—*CRL* and *CERCLIS*—may be simultaneously determined along with VCP and ICP; that is, they are potentially endogenous. In theory, participation could result in a site being added to the Confirmed Release List or to CERCLIS. A duration model controls for this problem because it

[8] For an introduction, see Keifer (1998).

explicitly accounts for the intertemporal relationship of these explanatory variables and participation: once a site joins the VCP or ICP, it drops out of the likelihood function, so the model only takes into consideration cases where listing precedes participation.[9]

A second reason for using a duration model is that it avoids the problem of "right censoring" that would arise in a simple cross-sectional dichotomous choice model because some of the plants that were not participating in July 2006, when our ECSI data were collected, could join subsequently. A duration model circumvents this problem by estimating the conditional probability of participation in each period.

We use a Cox (1975) proportional hazard model. There are two broad approaches to specifying duration models. One is to make parametric assumptions about the time-dependence of the probability density function, $f(t, \mathbf{X_t}, \beta)$. Common assumptions include exponential, Weibull, and log-logistic distributions. Each assumption implies a different shape for the baseline hazard function, $h_0(t)$.[10] A second general approach is to use a Cox (1975) proportional hazard model which does not require a parametric assumption about the density function. This feature accounts for the broad popularity of the Cox model among economists, and it is the reason we choose it. We use days as our temporal unit of analysis.

6. RESULTS

Table 2 presents regression results for the Cox proportional hazard model. Model 1 focuses on participation in the VCP and Model focuses on participation in the ICP. Because the hazard function given by equation (2) is nonlinear, the estimated coefficients do not have a simple interpretation (technically, they are the effect on the log hazard rate of a unit change in the explanatory variable at time t). Exponentiated coefficients, however, can be interpreted as the hazard ratio—that is, the ratio of the hazard rate given an increase in an explanatory variable at time t (a unit increase in a continuous variable or a change from 0 to 1 of a dichotomous dummy variable) relative to the baseline hazard rate at time t. A hazard ratio greater than 1 indicates that an increase in the explanatory variable increases the hazard rate relative to the baseline. For example, a hazard ratio of 2 means that an increase in the explanatory variable doubles the hazard rate relative to the baseline.

6.1. Voluntary Cleanup Program

Of the regulatory variables in Model 1, *CRL*, *PERMIT*, and *NW_REGION* are significant at the 5% level. As expected, both *CRL* and *PERMIT* are positively correlated with participation. The hazard ratios for these variables indicate that all other things equal, a site that has been placed on the Confirmed Release List is 28% more likely to join the

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[9] We are not able to account for the timing of *PERMIT* because the requisite data in ECSI are incomplete.

[10] For example, an exponential probability density function generates a flat hazard function, $h_0(t)$. The implication is that the probability of joining the VCP and ICP (apart from the influences of regulatory activity and site characteristics) stays the same over time. A log-logistic probability density function, on the other hand, generates a hazard function that rises and then falls.

VCP than a site that has not been listed and a site that has been permitted is 30% more likely to join the VCP than a site that has not been permitted. The regression results also indicate that the DEQ administrative region where the site is located affects the probability of participation: sites administered by the northwest DEQ region are 34% more likely to join than sites in the east region (the reference group). Evidently, listing a site in CERCLIS has no impact on the probability of participation.

Of the community characteristic variables, *TR_TIME* is significant at the 10% level. However, the magnitude of the effect is quite small. Surprisingly, *HOUSEVAL* is not significant, presumably because it is a poor proxy for the market value of the site. Of the prior use variables, all are significant at the 5% or 10% level. The largest effects are for *SIC4* and *SIC13*.

6.2. Independent Cleanup Pathway

Of the regulatory variables in Model 2, only *W_REGION* and N*W_REGION*, the two dummies that indicate which DEQ region administers the site are significant, both at the 1% level. The hazard ratios indicate that sites in the west region are 3.24 times more likely to participate in the ICP than sites in the east region, and sites in the northwest region are 2.57 times more likely to participate. Neither of the two community characteristics variables are significant. Finally, four of the prior use dummy variables are significant, all at the 5% level. The largest effects are for *SIC7* and *SIC9*.

6.3. Discussion

Three of the results from the empirical analysis are particularly noteworthy. First, both of Oregon's voluntary cleanup programs are attracting sites with significant contamination. This is evident from the simple summary statistics in Table 1 which indicate that 42% of the 613 sites in our sample that participated in the Oregon VCP, and 25% of the 155 sites that participated in the ICP were included by DEQ on the Confirmed Release List. Recall that two of the conditions for inclusion on this list are that contamination on the site has been confirmed and deemed significant by virtue of its quantity or hazard. This finding contrasts sharply with the situation in Colorado where, according to Alberini (2007) the state voluntary cleanup program almost exclusively attracts sites with minimal contamination and high development potential.

A second, related finding is that sites that DEQ includes on the Confirmed Release List are 28% more likely to join the VCP than sites that have not been listed, all other things equal. We hypothesize that listing a site enhances pressure for remediation that both regulators and non-regulatory stakeholders place on the site manager, thereby raising the expected benefit of participation. Note, however that listing does not drive participation in the ICP. The reason may be that the ICP, by virtue of the criteria and rules for participation, selects for sites where contamination is less severe and where remediation is relatively straightforward. Presumably, regulatory and non-regulatory pressures for remediating such sites are relatively low. If DEQ faces resources constraints that force it to focus on the most heavily contaminated sites, then managers of lightly contaminated sites know that their chances of being drafted into the mandatory Site Response Program are relatively minimal. Moreover, even if this does happen, the costs of mandatory cleanup are probably relatively low. Also, sites of the type that participate in the ICP probably face relatively little pressure from non-regulatory actors.

These two findings—the Oregon VCP is attracting sites with significant contamination and listed sites are more likely to join—are potentially important from a policy perspective. Together, they imply that the DEQ has been able to spur voluntary remediation of some contaminated sites by adding them to the Confirmed Release List.

A third noteworthy result is that sites with DEQ permits are more likely to participate in the VCP. We hypothesized that sites that are permitted are more likely to join partly because they face lower costs of doing so since DEQ is more likely to already know about potential contamination on permitted sites and managers of such sites are more likely to already be familiar with DEQ and its VCP. Without follow on research, we cannot be sure that this explanation is valid. However, it also hints at the potential importance of informational issues in explaining VCP participation.

7. CONCLUSION

We have presented an econometric analysis of participation in a state voluntary cleanup program. We have overcome the problem of assembling a control group of nonparticipating sites by focusing on a VCP in a state that maintains a registry of known contaminated sites. The regressors in our econometric analysis are site characteristics that aim to capture the benefits and costs of participation, including the expected savings that arise from avoiding the mandatory Site Response Program, and the cost of revealing to DEQ that a site is contaminated. We have used a duration model to account for the intertemporal relationship between our explanatory variables and participation, and to avoid right censoring.

Our results suggest that Oregon's voluntary cleanup programs are attracting sites with significant contamination, and that, all other things equal, sites that state regulators have formally added to a public list of sites with confirmed significant contamination are more likely to subsequently join one of the state's main voluntary programs. Together, these findings imply that state regulators can spur voluntary remediation of contaminated sites by collecting, verifying, and publicly disclosing information on contamination. This is a mechanism for encouraging VCP participation that, to our knowledge, has not yet received any attention in literature. Compared to some other policy tools frequently used to encourage participation in VCPs, it would appear to be relatively inexpensive. Our findings comport with a growing body of evidence that suggests public disclosure of environmental performance information is an efficient policy tool for promoting abatement and remediation.

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Table 1. Variables in econometric analysis: definition and sample means

Variable	Description	VCP Sample			ICP Sample		
		All n=1,680	**Parts. n=613**	**Nonparts. n=1,067**	**All n=1,642**	**Parts. n=155**	**Nonparts. n=1,487**
DEPENDENT							
VCP	Participant in Voluntary Cleanup Program?*	0.365	1	0	0.398	0.477	0.389
ICP	Participant in Independent Cleanup Pathway?*	0.107	0.109	0.105	0.094	1	0
INDEPENDENT							
Regulatory activity							
CRL	On Confirmed Release List?*	0.255	0.423	0.159	0.242	0.245	0.242
CERCLIS	In CERCLIS?*	0.168	0.119	0.197	0.155	0.084	0.162
PERMIT	Has DEQ permit?*	0.168	0.194	0.150	0.151	0.110	0.155
E_REGION	In DEQ eastern region?*	0.263	0.321	0.229	0.257	0.181	0.265
W_REGION	In DEQ western region?*	0.371	0.238	0.448	0.378	0.361	0.380
NW_REGION	In DEQ northwestern region?*	0.366	0.440	0.323	0.365	0.458	0.355
Neighborhood characteristics							
HOUSEVAL	Median house value in census block group ($)	142,237.1	145,068.4	140,610.5	142,564.6	158,785.8	140,873.7
TR_TIME	Med. travel time to work in census block group (min.)	12890.9	13,120.9	12,758.8	13042.9	14,051.8	12,937.7
Prior use							
SIC1	SIC div. A: ag., forestry, farming*	0.044	0.024	0.056	0.045	0.032	0.046
SIC2	SIC div. B: mining*	0.060	0.021	0.082	0.055	0.026	0.058
SIC3	SIC div. C: construction*	0.004	0.002	0.005	0.004	0.006	0.004
SIC4	SIC div. D, maj. grp. 24: mfg. wood products except furniture*	0.102	0.124	0.089	0.098	0.103	0.097
SIC5	SIC div. D, maj. grp. 28: mfg chemicals	0.027	0.016	0.034	0.027	0.026	0 .027
SIC6	SIC div. D, maj. grps. 33&34: primary metal except machinery and transportation*	0.039	0.046	0.035	0.034	0.032	0.034
SIC7	SIC div. D, other maj. grps: mfg. all other products*	0.076	0.078	0.074	0.072	0.077	0.071
SIC8	SIC div. E: transport, comm. electric, gas, and sanitary*	0.176	0.206	0.159	0.186	0.155	0.189
SIC9	SIC div. F: wholesale trade (includes bulk oil & salvage)*	0.100	0.124	0.086	0.094	0.110	0.093
SIC10	SIC div. G: retail trade*	0.107	0.093	0.115	0.110	0.097	0.111
SIC11	SIC div. H: finance, insurance, and real estate*	0	0	0	0	0	0
SIC12	SIC div. I: services (includes dry cleaning, auto repair)*	0.174	0.171	0.175	0.173	0.265	0.163
SIC13	SIC div. J: public administration (includes military)*	0.043	0.051	0.039	0.046	0.045	0.046
SIC14	Not classifiable*	0.049	0.044	0.052	0.056	0.026	0.059

*Dichotomous dummy variables (0/1)

Table 2. Duration regression results

Variable	Model 1 Dep. var. = VCP	Model 2 Dep. var. = ICP
Regulatory activity		
CRL	1.280** (0.125)	0.743 (0.167)
CERCLIS	1.024 (0.149)	1.455 (0.425)
PERMIT	1.303** (0.139)	0.956 (0.259)
W_REGION	1.122 (0.131)	3.240*** (0.815)
NW_REGION	1.342** (0.165)	2.577*** (0.737)
Neighborhood characteristics		
HOUSEVAL	1.000 (0.00000069)	1.000 (0.0000011)
TR_TIME	1.000* (0.000004)	1.000 (0.0000083)
Prior use		
SIC2	0.482* (0.191)	0.626 (0.449)
SIC4	3.379*** (1.040)	2.545* (1.296)
SIC5	2.440** (0.965)	2.777 (1.750)
SIC6	2.537*** (0.892)	2.449 (1.663)
SIC7	2.577*** (0.804)	3.022** (1.674)
SIC8	2.468*** (0.723)	1.911 (0.973)
SIC9	2.010** (0.603)	3.191** (1.634)
SIC10	2.094** (0.647)	2.362 (1.239)
SIC12	2.016** (0.591)	2.879** (1.432)
SIC13	2.615*** (0.892)	1.472 (0.855)
SIC14	2.156** (0.719)	1.130 (0.716)
Number of observations	1,680	1,642
Log pseudolikelihood	-3687.138	-771.856

(standard errors in parentheses)
* significant at 10% level
** significant at 5% level
*** significant at 1% level